are principally considered, objects suitable for examination with larger ones up to seven inches are given.

Much trouble has been taken with a very convenient result; and as the author shows what corrections to apply to make the volume useful in future years, we must regard it as one of the most useful books an amateur astronomer can possess.

Practical Introduction to Chemistry. By W. A. Shenstone. Lectures on Chemistry in Clifton College. (London: Rivingtons, 1886.)

ALTHOUGH several courses of practical chemistry for beginners have lately been introduced the author has not found any of them suitable for school work, and so he has undertaken to write one himself.

In his selection of experiments, he says he has been guided by two main considerations. First, that they should be suitable for the young boys who chiefly will have to perform them, and who will have but a limited amount of time to do them in. Secondly, that when completed they shall constitute a body of experience which shall be as valuable as possible to appeal to when the students pass to the classes which have lecture teaching.

The first three chapters deal briefly with the elements, compounds, acids, &c. Chapters IV. and V. deal with the law of chemical combination and the classification of chemical changes; Chapters VI. and VII. with the decomposition of water and air. Chapter VIII. is devoted to a few very elementary experiments on the relations between solids, liquids, and gases. In Chapters IX. and X. attention is drawn to the use made of these differences in experiment.

The appendixes contain a list of apparatus and also a description of the balance and how to use it.

The book is divided into two sections. In the first section the student is given instructions how to perform the experiments, but he is not told how they will "come out," so that as the experiment proceeds, he has to observe and note what takes place, and when it is finished he can compare his notes with those given in Section II., where full explanations are afforded. Certainly if this method is well carried out we shall have a vast improvement upon the ordinary "test tubing" process, in which, as a rule, little theoretical construction is given to the beginner. W.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*

[*The Editor urgently requests correspondents to keep their letters as short as possible. The pressure on his space is so great that it is impossible otherwise to insure the appearance even of communications containing interesting and novel facts.*]

Permanent Magnetic Polarity

SINCE the subject of the permanent polarity of quartz has been brought prominently forward by the researches of Dr. Tumlirz, published in the January number of *Wiedemann's Annalen*, and by the recent discussion of it in your pages, it is perhaps allowable for me to put on record the fact that I have been engaged during the course of this winter with very similar experiments, and have obtained very similar results. Quartz indeed does not happen to be one of the substances I have examined,—I rather dreaded the complexity of crystalline substances,—but my observations have led me to the conclusion that most likely *every* substance possesses some trace of permanent magnetisability or retentivity.

The set of experiments were not indeed begun with the object of looking for permanent polarity, but with a wholly different object, viz. this:—According to the Ampère-Weber theory of magnetism and diamagnetism, wherein magnetism is explained by means of specific molecular currents flowing in channels of no resistance, and diamagnetism by induced currents excited in those same channels by the magnetic field, it is obvious that the permeability of a magnetic body ought to become negative when the magnetising force applied oversteps a certain amount. Because an increasing magnetising force must weaken the specific currents, even though it is unable to excite contrary ones and so cause diamagnetism.

This result of the theory is pointed out by Clerk-Maxwell (vol. ii. § 844, 1st edit.), who further says: "If it should ever be experimentally proved that the temporary magnetisation of any substance first increases and then diminishes as the magnetising force is continually increased, the evidence of the existence of these molecular currents would, I think, be raised almost to the rank of a demonstration."

There are many circumstances now known which point more or less distinctly to such a maximum, but my ambition has been to not only establish a falling off of induced magnetism, but actually to reverse it; to convert, in fact, a feebly-magnetic substance into a diamagnetic substance by immersing it in a sufficiently intense magnetic field.

Accordingly, in October last, I set up a fairly large magnet, with specially-pointed pole-pieces about a centimetre or less apart, and arranged that various strengths of current, ranging from very weak to very strong, might be sent round its coils; the weakest current being given by a Leclanché or two, an intermediate strength by 3 or 4 secondary lead cells, a strong current by 24 such cells, and the greatest strength by about 40 secondary batteries, some of them zinc-lead with 2½ active volts apiece between their terminals, kept charged in two batches by a dynamo.

I then instructed my workshop-assistant, Mr. Benjamin Davies, to fill up his odd time by cutting ellipsoids of all manner of substances (axes about ·6, ·3, ·3), to finish them off with glass-paper, when practicable to boil them in acid, and then to examine their behaviour between the poles of the magnet in a specified way.

The dimensions of the magnet were:—

Diameter of iron core ... ... 5 centims.
Length of each leg ... ... 21 ,,
Distance from centre to centre ... 15 ,,
Total number of turns of No. 12 B.W.G. wire, 1868, on both legs together.
Resistance of wire 1·1 ohm.
Usual strengths of current, from ¼ ampere to 50 amperes.

The thing intended was to discover by trial some substance so feebly magnetic that, though it could just set itself axially with the weakest current, it might lie equatorially with the strongest. But failing this actual change of property it was thought that the rate of oscillation between the poles might diminish for some (non-conducting) substances when the highest powers were applied, instead of increasing.

And meanwhile the behaviour of all the substances was to be noted and carefully recorded, whatever it might be.

In this way a large number of substances, various kinds of wood, all sorts of metal, glass, coke, charcoal, wax, chalk, cardboard, ebonite, &c., have been passed under review; and some one or two of them seemed to behave exactly in the way hoped for. One piece of coke, for instance, vibrated in the intense field more slowly than it did in the feeble one; while another, which vibrated axially in a weak field, set itself nearly equatorially in the strong one. Its behaviour was thus sufficiently like what we wanted to justify a more careful examination.

Soon after this, however, Davies of his own accord inserted a reversing key into the circuit of the Leclanché, and thus made an important observation.

When the *strong* current was reversed, the deportment of the substance remained unaltered, as is natural enough; but directly the *weak* current was reversed, the little suspended piece turned in the magnetic field through 120° or so, and pointed in a symmetrically situate direction on the other side the magnetic axis. The piece of coke, for instance, which may have been pointing some 60° on the one side of the magnetic axis, changed its position when the magnet was reversed, and pointed some 60° on the other side. The suspending thread was not wholly devoid of torsion though it was extremely minute. A piece of electrolytic copper, and a piece of boxwood with the grain longways, were soon afterwards found, which set themselves almost exactly equatorially, and on reversing the magnet turned through very nearly 180°.

I was a little excited about this result at first, because I thought

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it meant a permanent diamagnetic polarity, that is to say, "*a diamagnet*," which seemed an incomprehensible result. My suspicions were at once aroused, however, as to the possibility of a transverse ordinary magnetisation; and subsequent experience, on the whole, confirms this explanation.

All the substances were then tried over again for permanent magnetic polarity, and not one of them has failed to show it. A piece of wood, for instance (or any other substance), which points axially between the poles, instantly reverses its position, turning through 180°, when the magnet is reversed. But the reversal must be done with the weak current only: anything like a strong current, *e.g.* that from two or three secondary cells, instantly destroys and reverses the permanent magnetism, and no abnormal behaviour is then detected. Some substances, however, retain it better than others. The permanent magnetism requires a strong current to excite it, and a very weak reverse current to detect it. Without these conditions it would certainly have been overlooked. It does not seem to matter whether a substance is magnetic or diamagnetic, it always reverses its position or nearly reverses it when the weak reverse current is applied.

The piece of copper was next *held* long-ways in the field, and a strong current applied. On now hanging it at 45° in the field, and testing it by a weak current, it at once returned to its axial position (though the copper was electrolytically "pure" and decidedly diamagnetic); on reversing the weak current, it at once turned through 180°, setting axially the other way, thus behaving exactly like a weak magnet. When a strong current was applied this behaviour was lost, the piece set itself nearly equatorially again, and the residual axial magnetism was either masked or lost. The reaction of induced currents naturally makes the examination of conducting masses rather troublesome.

During Christmas week Sir Wm. Thomson happened to pay the laboratory a hurried visit, and I showed him a piece of pitch-pine between the poles behaving exactly like a weak compass-needle; "a wooden magnet," as he at once called it. He was good enough to suggest a better mode of arranging the experiment for my original purpose of looking for the conversion of magnetism into diamagnetism: an arrangement which I have since adopted. So far, however, the results in this direction are very preliminary.

In all these experiments there is one flaw; and it is partly owing to this flaw that I have regarded them as unfit for publication. Indeed, I only send this note now because of the publication of Dr. Tumlirz's result. His experiment with quartz is very like one of mine, and it is very clearly and neatly described in his paper. But the same flaw, or what appeared to me to be such, seems to extend to his case also. What guarantee is there that no trace of iron is present,—perhaps as mere dirt, more likely as an infinitesimal ingredient of the substance? Several of the pieces of coke I used had been boiled for weeks in several lots of hydrochloric acid, and the last few washings gave no ferrocyanide coloration; but I have no doubt the coke yet contains iron. Possibly the other substances do too.

Suppose, now, a substance contains a trace of iron, which iron is susceptible of permanent magnetism, no matter how feeble: then, no matter whether the substance itself be paramagnetic or diamagnetic, in an intense field its own properties will altogether overpower those of the trace of iron, for this trace may be considered as magnetically saturated and done for at once. But suppose the substance next finds itself in a very weak field: the induced magnetism and the force depending on it, since they vary as the square of the field, are vanishing quantities; any trace of residual or permanent magnetism has it all its own way.

What way is there of proving that not a trace of iron exists in a body? Chemical tests are surely futile compared with the test of a magnet. I see at present no way out of the difficulty.

And would not the same difficulty recur in connection with my original notion? I believe it would. Suppose I succeeded in finding a substance, paramagnetic in a weak field, diamagnetic in a strong one; it would be open to any one to object that the paramagnetism was due to a trace of magnetic impurity: that this impurity, being intrinsically highly susceptible, causes all the observed action in a weak field, but that it soon becomes saturated as the field increases in strength, and that then its force is altogether overpowered by the main bulk of less susceptible substance, whose saturation-point, if existent at all, is miles higher up. This substance then regulates the behaviour of the body, and, according as it is diamagnetic or magnetic, the whole body behaves diamagnetically or magnetically.

Notwithstanding the prevision of this difficulty, I determined to try the experiments, not knowing what might come of them, and thinking that a body which could be made magnetic or diamagnetic at pleasure would be of some interest, however its behaviour might be explained. I even thought of artificially constructing such a body by incorporating a trace of iron in a lump of bismuth, or by using semi-purified commercial bismuth. I have not done this yet, however, and accordingly do not know if it be possible.

That which has come, so far, of these experiments, viz. the apparent existence of magnetic retentivity in all matter, is in itself not an improbable result; rather, one might say it is a probable one; and although it may be possible to explain it by a trace of iron impurity, it by no means follows that this disappointing sort of explanation is the correct one.

The singular fact which most strongly suggests the need for some such explanation is that diamagnetic bodies are capable of ordinary permanent magnetism. It is true that on the Weber-Ampère theory the specific molecular current of a diamagnetic substance need not be zero but may have a small positive value, which is easily destroyed and reversed by a powerful field, but which yet may endow the substance with magnetic properties in a weak field. But the worst of it is that I have never been able to detect any trace of paramagnetic property, in a diamagnetic substance, other than this permanent or residual polarity excited by immersion in a strong field.

The only suggestion I can make is the following.

Let the molecular channels in a diamagnetic substance be not wholly free from resistance, though their resistance must be very small; let induced currents be excited in these channels by immersion in a magnetic field, and let them have time to dissipate a little energy and begin to die away before the field is removed. On now destroying the field, the inverse induction will more than destroy the previously induced currents, and will leave a residue of opposite current in the molecules; the body will therefore behave as a weak magnet, until these residual currents die away.

I must examine more carefully the excitation and decay of the permanent magnetism with time. With wood it seems to be a question of hours.

These dissipation experiments are very important and should be seriously attempted in several directions with proper appliances and funds. Thus: gas molecules appear to be perfectly elastic, or rather their impact coefficient of restitution is supposed to be unity, but if a box of gas be shut up in infinitely adiabatic cotton-wool for a century, will it have gone colder?

Again, iron molecules are supposed to be infinitely conducting, and their Ampère currents seem permanent; but if the moment of a bar were measured from time to time against gravity, when a given current circulated in a given helix round it, would it be found that age impaired its strength?

Once more, bismuth is supposed to be diamagnetic by reason of its non-resisting channels; but suppose a piece of bismuth is left in a constant magnetic field for a year, will it have lost some of its diamagnetic property? and when taken out will it be found magnetic for a time?

It may be remarked that, whereas it is certain (on Ampère's theory) that iron molecules are almost infinitely conducting, we have no similar assurance for bismuth; it is even possible to surmise that a body may tend to become diamagnetic in proportion as it chokes off its own molecular currents, while magnetic bodies are such as retain them perennially without apparent loss. If such were the case, diamagnetism would sometimes improve with age.

I am, of course, aware that there is another, and merely differential, theory of diamagnetism, but this leaves magnetism itself wholly explained; whereas, directly the Ampère theory of magnetism is even provisionally accepted, the Pruth of infinite molecular conductivity is already crossed, and the Weber theory of diamagnetism follows as a natural and indeed inevitable consequence. OLIVER LODGE

University College, Liverpool, March 15

Dissociation and Contact-Action

IN a recent issue (NATURE, vol. xxxiii. pp. 350-51) you drew attention in your "Chemical Notes" to some recent researches of M. Konovaloff on "contact-actions," and to the suggestion made by him that "the dissociation (in the cases referred to) was a consequence of the contact-action of the solid body." On

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